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ABSTRACT

This report discusses Senate Bill no. 272, which provides for a coordinated federal research and development program to ensure continued U.S. leadership in high-performance computing. High performance computing is defined as representing the leading edge of technological advancement in computing, i.e., the most sophisticated computer chips, the fastest computers with the largest memories, the fastest algorithms, and the fastest computer networks. This report documents the background of the bill, the growth of fiber optic networks, and prior administrative and congressional action. A summary of the major provisions of the bill precedes analyses of each of the 10 sections of the bill, including the National High-Performance Computing Program, the role of the National Research and Education Network (NREN), the goal of the National Aeronautics and Space Administration (NASA), the role of the National Institute of Standards and Technology (NIST), the role of the National Science Foundation (NSF), and the continuing development of supercomputers in light of international competition. The report concludes with the presentation of new materials in S. 272 that would change the provisions of Title VII of the National Science and Technology Policy, Organization and Priorities Act of 1976. (DB)

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ED332693

Calendar No. 87

102D CONGRESS *1st Session*	SENATE	REPORT 102-57

HIGH-PERFORMANCE COMPUTING ACT OF 1991

Mr. HOLLINGS, from the Committee on Commerce, Science, and Transportation, submitted the following

REPORT

OF THE

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ON

S. 272

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
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Calendar No. 87

102D CONGRESS
1st Session

SENATE

REPORT
102-57

HIGH-PERFORMANCE COMPUTING ACT OF 1991

MAY 16 (legislative day, APRIL 25), 1991.—Ordered to be printed

Mr. HOLLINGS, from the Committee on Commerce, Science, and Transportation, submitted the following

REPORT

[To accompany S. 272]

The Committee on Commerce, Science, and Transportation, to which was referred the bill (S. 272) to provide for a coordinated Federal research program to ensure continued U.S. leadership in high-performance computing, having considered the same, reports favorably thereon with an amendment in the nature of a substitute and an amendment to the title and recommends that the bill as amended do pass.

PURPOSE OF THE BILL

The primary objective of the legislation is to accelerate research, development, and application of high-performance computing in research, education, and industry. High performance computing represents the leading edge of computing technology—the most sophisticated computer chips, the fastest computers with the largest memories, the fastest algorithms, and the fastest networks.

The reported bill authorizes Federal funding for the development and use of new supercomputers, advanced software, and a National Research and Education Network (NREN), a computer network capable of transmitting billions of bits (gigabits) of data per second. In total, the bill authorizes $650 million to the National Science Foundation (NSF), $338 million to the National Aeronautics and Space Administration (NASA), and $31 million to the National Institute of Standards and Technology (NIST) for fiscal years (FY) 1992-96.

The bill also establishes a High-Performance Computing (HPC) Program involving NSF, NASA, NIST, the Department of Energy (DOE), and the Defense Advanced Research Projects Agency

(DARPA) of the Department of Defense (DOD), as well as other agencies. This program would be planned and coordinated by the White House Office of Science and Technology Policy (OSTP).

Background and Needs

IMPORTANCE OF COMPUTING

In the last 30 years, computer technology has transformed American science and industry. Today, computers are indispensable tools found in almost every laboratory, office, and factory. They have enabled researchers to solve previously unsolvable problems; have transformed the way products are designed, manufactured, and marketed; have changed the way offices are operated; and have given teachers a new, powerful educational tool. These advancements have been made possible by an incredibly rapid improvement in computer technology, which have been spurred in part by Federal investments in research and development.

IMPORTANCE OF HIGH-PERFORMANCE COMPUTING

Today high-performance computing is being applied in more and more fields, helping to improve U.S. research, education, economic competitiveness, and national security. Supercomputers, which are commonly defined as the most powerful computers available at any given time, are now considered essential in many fields of science and engineering. Today's supercomputers usually cost between $1 million and $20 million, are 1,000 to 100,000 times more powerful than a typical personal computer, and are capable of making billions of mathematical calculations per second, about 50 to 100 times faster than the fastest computers available just 10 years ago.

Using complex computer "models," researchers now can simulate and test advanced aircraft designs, proposed new drugs, and new manufacturing techniques. Scientists have used supercomputer models to understand better the Earth's climate and weather, the Nation's economy, and the evolution of our galaxy.

FIBER OPTIC NETWORKS

To facilitate communication between researchers, students, and educators, and to promote the use of advanced computers, NSF and other Federal agencies have established fiber optic computer networks, which link researchers around the country to supercomputers, to other computing facilities, and to each other. Today over 500 colleges and universities are linked by NSF's NSFNET, which is the largest component of the Internet, a network consisting of hundreds of Federal research networks, State networks, and private networks, all interconnected.

Unlike copper telephone wires, optical fiber is capable of carrying the billions of bits of data generated every second by supercomputers. Such high data rates are needed because, for many types of computer models, scientists need sophisticated "visualization" techniques to sort out their results. Computer graphics can allow researchers to decipher data sets so large that they could fill hundreds of pages of computer printouts. Unfortunately, most computer networks operate at speeds of 1.5 million bits (megabits) per

second or less, and thus network users cannot utilize fully supercomputers.

To give researchers in universities and industry full access to supercomputers and other facilities, S. 272 would fund the NREN, a nationwide high-capacity computer network. Such a network would enable researchers and students to use supercomputers even if their institutions or companies could not afford to buy one of their own.

In addition to providing links with large computer centers, such networks can carry electronic mail between individuals around the country, allowing researchers to exchange papers, data, and video images. The NREN also would allow researchers to retrieve huge volumes of data (e.g. satellite images) from data bases and to share their own data with others. A multi-gigabit network, like the NREN, would allow scientists and engineers to control and collect data from research facilities (e.g. particle accelerators and radio telescopes) from thousands of miles away, reducing the need for expensive, time-consuming travel. Furthermore, such a national high-speed network would allow researchers around the country to collaborate over the network as effectively as they could face-to-face, leading to the creation of what has been termed a National Collaboratory.

In recent years, support has been growing in both Congress and within the Administration for an increase in Federal funding for high-performance computing. A November 1985, White House Science Council report, "Research in Very High Performance Computing," states: "The bottom line is that any country which seeks to control its future must effectively exploit high-performance computing. A country which aspires to military leadership must dominate, if not control, high-performance computing. A country seeking economic strength in the information age must lead in the development and application of high-performance computing in industry and research." At a July 21, 1989, Committee hearing, Dr. Allan Bromley, the President's Science Advisor and Director of OSTP, stated that high-performance computing must be "a very high priority" because "it has a catalytic effect on just about any brand of research and development" and "will, eventually, transform industry, education, and virtually every sector of our economy, bringing higher productivity and enhanced competitiveness." In Congress, several hearings have been held on high-performance computing, and several bills have been introduced. Last year, in the 101st Congress, the Senate unanimously approved legislation that would have authorized almost $1.7 billion in new funding over the next five years for a HPC Program.

ADMINISTRATION ACTION

While the Administration has endorsed neither the full five-year program approved by the Senate last Congress nor S. 272, in its FY 1992 budget request, it included $638 million for the first year of a multi-agency HPC and Communications Program, very similar to that outlined in the OSTP reports and S. 272 as reported. The request would increase Federal funding for high-performance computing research and development by $149 million (a 30 percent in-

crease) over FY 1991 levels. The principal agencies involved in the program are NSF, NASA, DOE, and DARPA. In addition, NIST, the National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), and the National Institutes of Health (NIH) (particularly the National Library of Medicine) all have important roles. As in S. 272 as reported, this program would be coordinated by OSTP.

CONGRESSIONAL ACTION

In order to spur development of faster computer networks and more advanced supercomputers, in 1986, the Commerce Committee approved S. 2594, the Supercomputer Network Study Act, which required OSTP to provide Congress with an analysis of the computer networking needs of American researchers and the benefits and opportunities that a national high-speed fiber optic network for computers and supercomputers would provide. That legislation was enacted as part of the NSF Authorization Act for FY 1987 (P.L. 99-383).

As required by the legislation, OSTP released a report in December 1987, entitled "A Research and Development Strategy for High Performance Computing," which outlined an ambitious, comprehensive research program in supercomputing and computer networking, and proposed that the Federal Government spend an additional $1.74 billion over the next five years on high-performance computing.

In 1988, S. 2918 was introduced to create a National HPC Program, similar to that outlined in the OSTP report. The following year, S. 1067, the National High-Performance Computing Act of 1989, was introduced, authorizing funds for high-performance computing at NSF, NASA, DOE, and DARPA. Further details were provided by an implementation plan entitled "The Federal High-Performance Computing Program," developed by over 12 agencies and released by OSTP in September 1989.

S. 272

The High-Performance Computing Act of 1991 is similar to S. 1067. Like S. 1067, it would establish a multi-agency HPC Program that would be coordinated through the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), which is chaired by the Director of OSTP. In recent years, FCCSET has provided critically-needed, high-level interagency coordination of research in a number of areas, most notably global change. The program would be a comprehensive one, with four elements: high-performance computers, software technology and algorithms, networking, and basic research and human resources. While the program in S. 272 is very similar to the HPC and Communications Program proposed by the Administration, it would authorize five years of funding for three agencies, NSF, NASA, and NIST, whereas the Administration has so far only called for funding for the first year (FY 1992) of the program—the Administration has requested $638 million in FY 1992, as compared to the $71 million figure for FY 1992 in S. 272, and has requested funding for eight federal agencies.

To fully reap the benefits of high-performance computing, the Federal Government needs to implement a comprehensive research and development program similar to that provided for in the reported bill. Because the components of the program are all closely linked, progress in high-performance computing will be hindered if the pace of development in any one area is not as fast as in other areas. For instance, if a national high-speed computer network were established, but if faster, more powerful supercomputers were not developed to handle the data that would flow across such a network, the result would be missed opportunities and wasted resources. Similarly, the development of faster supercomputers, without the development of the software needed to utilize them effectively and of networks to access them, would be a poor investment of research funds. Clearly, there is a need for a balanced, comprehensive approach.

BENEFITS OF S. 272

Most of the funding authorized in S. 272 is in support of basic research. There is broad agreement on the need in general for the Federal funding of basic research—basic research has been shown repeatedly to be a very good investment. For example, a recent study by Dr. Edwin Mansfield of the University of Pennsylvania estimated that the annual rate of return on Federal investments in academic research is approximately 28 percent.

The return on investments in basic research on high-performance computing may be even higher. On July 26, 1989, in testimony before the Science, Technology, and Space Subcommittee, Dr. James H. Clark, Chairman and Founder of Silicon Graphics Computer Systems, told how a single $12 million DARPA research grant which Dr. Clark and his colleagues received while he was a professor at Stanford from 1979 to 1982 led directly to the creation of SUN Microsystems, Silicon Graphics Computer Systems, and MIPS Computer Systems. Today, just nine years later, these three computer companies have combined total revenues of almost $2.5 billion per year and an average annual growth rate of 60 percent.

In addition, because high-performance computing represents an enabling technology which can increase greatly the productivity not just of computer scientists, but also of researchers in almost all fields of science and engineering, the returns are likely to be greater than the average return on investments in basic research. This research will lead to faster, more powerful computers that can tackle previously unsolvable problems; faster networks that can provide easier access to data and promote collaboration between researchers; and better software that can reduce the time spent computing the solution to a particular problem and thus allow researchers time to explore more facets of a problem.

The investment proposed by the reported bill would provide needed tools for federally-funded researchers and enhance greatly their productivity. At a June 21, 1989, hearing of the Science, Technology, and Space Subcommittee, Dr. William Wulf, then Assistant Director of NSF's Directorate for Computer and Information Science and Engineering, testified that supercomputing and high-speed networking can increase the productivity of many American

researchers by 100 percent, 200 percent, or more. Given that the Federal Government invests approximately $70 billion a year in research and development, such a productivity gain could produce enormous benefits and more than pay for the approximately $2 billion in additional funding needed for the proposed HPC Program for the next five years.

High-performance computing will allow researchers to tackle previously unsolvable problems, with huge benefits to society. For instance, better models of global climate change would lead to better policies to address global warming, policies which could have trillion-dollar impacts. Supercomputing could lead to a better understanding of AIDS, cancer, and genetic diseases, leading to breakthroughs impossible without more computing power.

Just as important as the benefits to American researchers are the benefits for American industry. Supercomputers are routinely used by automobile companies, both to design and to "crash test" cars; energy companies use them to analyze seismic data and prospect for oil; and even financial markets now utilize them to get real-time analyses of market behavior. On June 21, 1989, Mr. John Rollwagen, Chief Executive Officer of Cray Research, Inc., testified before the Science, Technology, and Space Subcommittee that ARCO used a Cray supercomputer to determine how to increase production of its Prudhoe Bay oil field by two percent, which translated into an additional $2 billion in profits. The engines on Boeing's new 737 airplane were designed using a supercomputer and as a result are 30 percent more efficient than earlier models. ALCOA used supercomputer models to reduce the amount of aluminum needed to produce a soda can by 10 percent, resulting in billions of dollars in reduced materials, production, and transportation costs.

While estimating the benefits of investment called for in S. 272 is difficult, it is clear that it would pay huge dividends. Dr. Bromley, testifying at a March 5, 1991, hearing of the Subcommittee on Science, Technology, and Space, cited a draft report from the Gartner Group which used economic models to estimate that the HPC Program established by S. 272 would lead to an increase in the U.S. gross national product of $170 billion to $500 billion between now and the year 2000.

In the United States, the most extensive use of supercomputers has been for defense and aerospace applications. The National Security Agency (NSA) relies heavily on the fastest supercomputers for signal processing and breaking codes. Supercomputers are essential for anti-submarine warfare and for the design of new weapons systems. The Strategic Defense Initiative and other military research and development projects rely heavily on supercomputer modeling. NASA has several supercomputers devoted to modeling the aerodynamics of aircraft and spacecraft. These supercomputers can be used to replace or complement expensive wind tunnel tests.

In the future, high-performance computing will be utilized increasingly by the education and library communities. Supercomputers can store and sort through huge quantities of data, and with optical disk storage systems it is possible to store entire libraries of information electronically and retrieve them in seconds. The Library of Congress and other libraries are starting to develop the

technology needed for "digital libraries" of books, journals, images, music, and videos—all stored in digital form and accessible over computer networks. The high-performance computing hardware and software developed pursuant to S. 272 as reported would facilitate creation of such digital libraries, and the NREN would provide easy access to them.

At present, a great deal of scientific and economic data is stored in electronic form, but much of it, especially remote-sensing satellite data, is almost inaccessible to those who might wish to use it. Making data sets like those at the Earth Resources Observation System (EROS) Data Center accessible over the NREN and other networks would enhance greatly the usefulness of these data sets and ensure that the United States maximizes the return on its investment in the collection of that data.

One of the most far-reaching impacts of the reported bill will be in the area of high-speed, fiber-optic telecommunications technology. Fiber-optic cable can transmit billions and even trillions of bits of data per second, thousands of times more than long-distance copper telephone cables. Scientists and engineers are using this new capability to develop technology for teleconferencing, for transmitting high-definition television (HDTV) programming, and for improving communication and collaboration among computer users.

In the future, this technology will be as commonplace and ubiquitous as the telephone is today. Fiber optic cable will reach every city and town, every school and business, large and small. Rural areas especially will benefit from the services that fiber optic networks will provide, since they will provide access to information and other resources otherwise available only in major metropolitan areas. Small businesses in rural areas (and elsewhere) will be able to use such networks to gain access to markets and experts throughout the country. Because of the importance of telecommunications to rural areas, it is essential that the NREN extend to colleges and universities in less-populated areas so that these areas can develop the infrastructure and expertise needed to reap all the benefits of high-speed networking. Although it will be several years before fiber optic cable is laid in many rural areas, satellite communications technology like that developed for NASA's Advanced Communications Technology Satellite (ACTS) and other systems could be used to provide high-speed communications links to the NREN in the interim.

By creating a national, high-speed computer network, this bill would provide a demonstration of the potential of high-speed fiber optic computer networks. Under this bill, the Federal funding called for will fund development of applications for a high-speed national network, lead to development of standards for such a network, and guarantee a market for commercial high-speed networking services, thus stimulating private sector investment in multi-gigabit networking. The technology and standards developed will be available publicly and will be applied quickly by private companies building commercial multi-gigabit networks. At present, the private sector is reluctant to make the multi-billion-dollar investments needed to build a national multi-gigabit network, in part because the technology has not been demonstrated and the market

has not been proven. At an October 4, 1989, hearing of the House Committee on Energy and Commerce's Subcommittee on Telecommunication and Finance, John Edwards from Northern Telecom testified that Federal funding authorized by this bill could accelerate the creation of a national, multi-gigabit network by five to ten years. Like the interstate freeway system and other types of infrastructure, such a network clearly would provide significant benefits to all sectors of the American economy.

HPC AND U.S. COMPETITIVENESS

The development of high-performance computing will have a significant impact on U.S. technological competitiveness, particularly given the efforts of other countries to develop a supercomputing capability. The Japanese and other foreign competitors recognize the benefits of supercomputing and fiber optic networks. In fact, the Japanese have focused significant efforts on becoming competitive in the world supercomputer market and are now producing some of the fastest supercomputers available. In April 1990, Japan announced a major research program to accelerate research and development on parallel processing supercomputers. In March 1990, the European Community announced a $1.3 billion a year high-performance computing program, which would fund high-speed networks, supercomputing centers, supercomputing hardware and software development, supercomputing applications, and education. Similarly, other countries are making massive investments in high-speed fiber optic networks. Japan's Nippon Telegraph and Telephone Corportation has announced that it intends to invest $126 billion to install a national fiber optic network which would reach every home, office, and factory in Japan by the year 2015 and be capable of transmitting hundreds of millions of bits of data per second. The Europeans are developing initiatives to build their own high-speed networks as part of EC 92.

Without additional Federal and private sector investment in supercomputing, the United States risks losing the $2.4 billion world supercomputer market, and more importantly, it risks having to rely upon foreign suppliers for an essential tool for improving research and development, for increasing American competitiveness, and for enhancing U.S. national security. The funding authorized by S. 272 as reported would help the United States maintain its lead in the development and application of supercomputers.

NEED FOR ADDITIONAL HPC FUNDING

Several agencies, including NSF, NASA, DARPA, and DOE have long histories of supporting basic research in computer science and computer technology. In addition, they have funded efforts to apply more broadly high-performance computing to scientific and engineering problems. To provide supercomputing services to American researchers, the NSF created five Supercomputer Centers in the mid-1980s. For FY 1992, NSF is requesting $66.80 million to fund the Centers. Other Federal agencies, including the NASA and the DOE, also maintain large supercomputers for use by Federal and academic scientists.

The NSF Supercomputing Centers provide the only access to leading-edge computing resources for over 15,000 research, educators, and students. These Centers have been extremely successful in preparing a new generation of scientists and engineering who are trained in "computational science"—the simulation or modeling of phenomena on a computer. Computational science is a relatively new approach to scientific research that complements the traditional methods of laboratory experimentation and theoretical investigation. The NSF Supercomputing Centers and other academic supercomputer centers have been particularly successful in bringing together academic and industrial researchers to apply computational science to important problems in the engineering, design, and manufacturing sectors.

The science agencies also fund several computer networks, including NSF's NSFNET, NASA's NASNET and SPAN (Space Physics Analysis Network), DOE's MFENET and HEPNET, and DOD's MILNET. Together with many State-funded or for-profit regional networks, several of these networks are linked by the Internet, which consists of over 2,000 interconnected networks. While it is not known exactly how many computers communicate via Internet, most estimates are that well over 100,000 computers are linked in this way.

However, present supercomputing and networking programs are not adequate to meet the needs of researchers. The supercomputers at the NSF Centers are chronically over-subscribed. DARPA and other agencies which fund development of new supercomputers lack the money to fund more than a small fraction of the promising proposals for new types of machines, which can cost from $10 million to $500 million to prototype. Furthermore, researchers are often frustrated by the lack of useful research software for supercomputers, which stems from the lack of adequate funding for supercomputer software development.

Perhaps even more importantly, inadequate funding levels would result in a delay in the establishment of the NREN. The NREN would be capable of transmitting gigabits (billions of bits) of data per second, and by 1996 would link up to 1,300 institutions and about a million researchers nationwide. The NREN would be about 2,000 times faster than the current NSFNET. While this nationwide computer network links over 500 institutions in all 50 States, its data rate is only 1.5 million bits per second, more than a thousand times slower than the proposed NREN. Even after NSFNET is upgraded to 45 million bits per second this year, researchers will be unable to utilize fully the supercomputers and data bases connected to it. Since use of NSFNET is growing at more than 15 percent a month, its new capacity will not be enough to accommodate the increased usage expected in the next two or three years. For FY 1992, NSF has requested $32.59 million for NSFNET. To develop a multi-gigabit NREN, additional funding for both NSF and DARPA will be required in coming years.

The multi-gigabit NREN is needed if researchers are to use the new networking technology being developed in laboratories around the country. The first computer networks, built in the late 1960s, enabled computers to exchange data at rates of a few thousand bits of data a second (a single page of double-spaced text represents

about 10,000 bits of data). Today, there are experimental computer networks that can transmit billions of bits of data a second, enabling computer users to share computer graphics and huge volumes of data in a few seconds. At a billion bits a second, an entire encyclopedia set could be transmitted to any computer on the network in less than a second. Unfortunately, these experimental networks are limited, connecting only a few computers. More research and development will be needed before the NREN, which will connect thousands of computers, can be built.

The funding authorized by S. 272 as reported would roughly double funding for supercomputing at NSF and NASA over the next five years, would roughly triple NSF's networking budget, and greatly expand NIST's computer research programs. These funding increases parallel those outlined in the 1987 OSTP report and the follow-up report released in September 1989, "The Federal High Performance Computing Program." Without this additional multi-year funding, researchers will not have access to the supercomputing resources they need; the NREN will be delayed; development of new, more powerful machines will be delayed; supercomputer software development will slow; and insufficient numbers of scientists and engineers will be trained to use supercomputers.

Legislative History

In October 1988, legislation was first introduced to authorize a multi-agency HPC Program. A revised version of the legislation, S. 1067, was introduced in May 1989 and reported by the Commerce Committee. An amended version of S. 1067, including provisions of S. 1976, a companion bill reported by the Senate Committee on Energy and Natural Resources, passed the Senate by voice vote in late October 1990. Although the House Science, Research, and Technology Subcommittee conducted two hearings on the House version of the bill (H.R. 3131), the House did not consider it before Congress adjourned. That Congress, funding for DARPA's portion of the HPC program was authorized and appropriated in other legislation.

On January 24, 1991, Senator Gore introduced S. 272, which is very similar to the first title of the version of S. 1067 that passed the Senate last year. It has 18 cosponsors, including Senators Hollings, Pressler, Ford, Breaux, Robb, Kerry, Kasten, and Gorton on the Committee. A companion bill (H.R. 656) was introduced in the House.

On March 5, 1991, the Subcommittee on Science, Technology, and Space held a hearing on S. 272. Witnesses at the hearing included representatives from computer, telecommunications, and other high-tech companies, and academia. Witnesses testified on the many new applications of supercomputing, and endorsed the idea of a NREN. Dr. D. Allan Bromley, White House Science Advisor and Director of OSTP, testifying for the Administration, stated that while the Administration endorsed the goals of the legislation, it opposes S. 272 because it might limit the flexibility of the Federal agencies implementing the HPC program mandated by S. 272.

At its March 19, 1991, executive session, the Committee considered in open session and adopted without objection an amendment

in the nature of a substitute for S. 272, which included a number of minor changes to the bill as introduced. The most significant was the addition of an authorization for NIST of $31 million for FY 1992–96.

On February 5, 1991, Senator Johnston introduced S. 343, the Department of Energy High-Performance Computing Act, which would define and authorize DOE's part of the multi-agency program established in S. 272. S. 343 is quite similar to the second title of the version of S. 1067 that passed the Senate last year. The Energy Committee held a hearing on S. 343 on April 11, 1991.

Summary of Major Provisions

As reported, S. 272 would authorize a five-year, multi-agency program providing an increase in Federal funding for research and development on supercomputers, advanced computer software, and computer networks. The major provisions are as follows.

Section 4 amends the National Science and Technology Policy, Organization, and Priorities Act of 1976, which established OSTP. The section establishes an interagency national HPC program involving NSF, NASA, DOE, DARPA, and other relevant agencies. Interagency coordination and planning for the program would be provided by OSTP's FCCSET, which is to work closely with industry. The program would be a comprehensive one, dealing with high-performance computing hardware and software, networking, and education and training in high-performance computing.

Section 5 requires NSF, DQD, DOE, NASA, and other agencies to provide for deployment of a multi-gigabit NREN by 1996. NSF would be the lead agency responsible for coordinating the work of the agencies contributing to deployment of the NREN. NSF is to have primary responsibility for connecting colleges, universities, and libraries to the NREN. The FCCSET is to provide for the planning and oversight needed to coordinate the efforts of the agencies contributing and using the NREN.

Section 6 defines several specific roles for NSF, including funding basic research and education, providing supercomputer access and networking services to researchers, enhancing development of information services available on the NREN, and promoting development and distribution of research software for supercomputers. The authorizations to NSF for FY 1992–96 total $650 million.

Section 7 mandates that NASA conduct basic and applied research in high-performance computing, particularly in the field of computational science, with emphasis on aeronautics and the processing of remote sensing and space science data. The authorizations to NASA for FY 1992–96 total $338 million.

Section 8 defines the role of NIST in high-performance computing. NIST is to adopt standards and guidelines for interoperability of high-performance computers, so that different types of computers could exchange effectively data over networks. NIST also is to be responsible for developing benchmark tests for evaluating high-performance computer systems. In accord with the Computer Security Act of 1987, NIST will provide for computer security and the privacy of information for Federal computer systems. The authorizations to NIST FY 1992–96 total $31 million.

Section 9 instructs the Secretary of Commerce to evaluate the impact of Federal procurement rules for software on development of new, improved software technology.

Section 10 contains miscellaneous provisions exempting computer systems used for classified programs and intelligence programs from provisions of the reported bill. In addition, Federal agencies are instructed to procure prototype and early production models of new high-performance computing systems.

Estimated Costs

In accordance with paragraph 11(a) of rule XXVI of the Standing Rules of the Senate and section 403 of the Congressional Budget Act of 1974, the Committee provides the following cost estimate, prepared by the Congressional Budget Office:

U.S. Congress,
Congressional Budget Office,
Washington, DC, April 5, 1991.

Hon. Ernest F. Hollings,
Chairman, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, DC.

Dear Mr. Chairman: The Congressional Budget Office has prepared the attached cost estimate for S. 272, the High-Performance Computing Act of 1991. Enactment of S. 272 would not affect direct spending or receipts. Therefore, pay-as-you-go procedures would not apply to the bill.

If you wish further details on this estimate, we will be pleased to provide them.

Sincerely,

Robert D. Reischauer, *Director.*

CONGRESSIONAL BUDGET OFFICE COST ESTIMATE

1. Bill number: S. 272.
2. Bill title: The High-Performance Computing Act of 1991.
3. Bill status: As ordered reported by the Senate Committee on Commerce, Science, and Transportation, March 19, 1991.
4. Bill purpose: S. 272 would require the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET) to develop and implement a National High Performance Computing Plan. It would also mandate that the National Science Foundation (NSF), in conjunction with the Department of Defense (DoD), the National Aeronautics and Space Administration (NASA), and other relevant federal agencies, establish a national network of high-speed computers, which would be known as the National Research and Education Network (NREN). The National Institute of Standards and Technology (NIST), a part of the Department of Commerce, would be charged with developing government-wide standards for computer networks.

The requirements of S. 272 would affect numerous federal agencies as developers and users of the NREN. For example, the bill would require the NSF and NASA to help develop software for the types of computers used in the network, and the DoD through the Defense Advanced Research Projects Agency (DARPA), would have

primary responsibility for research and development on technology needed for the network. The FCCSET would have the general responsibility for overseeing and coordinating the work of the agencies involved in this project. The Secretary of Commerce would be charged with conducting a study of the impact of federal procurement regulations regarding the rights to proprietary software provided by contractors.

To fund development of the network, the bill would authorize appropriations to the NSF, NASA, and NIST of about $1 billion over five years. The bill would also authorize NSF to charge a fee for use of the system.

5. Estimated cost to the Federal Government:

[By fiscal year, in millions of dollars]

	1992	1993	1994	1995	1996
Authorizations:					
National Science Foundation	46	88	145	172	199
National, Aeronautics and Space Administration	22	45	67	89	115
National Institute of Standards and Technology	3	4	6	8	10
Total authorization level	71	137	218	269	324
Estimated outlays	35	95	167	232	289

In addition to the funding specifically authorized in the bill, other agencies would incur costs to implement the bill's objectives. The bill has adopted goals and strategies for the program that are rouhgly in line with proposals from the Administration, as reported by the Office of Science and Technology Policy, and proposed in the 1992 President's budget. Some of the activities mandated by the bill are already underway.

The President's budget proposed 1992 funding increases totaling $149 million for high-performance computing and communications. This includes $49 million for DARPA and $28 million for the Department of Energy (DOE), for which the bill does not provide specific authorizations. Five-year funding needs above the 1991 program levels could be $700 million to $800 million for DARPA and $300 million to $400 million for DOE.

The costs of the specific authorizations would be in budget functions 250 and 370. Other significant costs would fall in functions 050 to 270.

Basis of Estimate: This estimate assumes that the full amounts authorized would be appropriated for each fiscal year. The estimated outlays are based on historical spending patterns.

CBO expects that fees for use of the network would be phased in once the network is operating, which would probably be in 1994 or later. Receipts from these fees could ultimately provide a significant offset to the operating costs of the network. Nevertheless, we do not expect that receipts would be significant during the five-year period covered by this estimate.

6. Pay-as-you-go considerations: The Budget Enforcement Act of 1990 set up pay-as-you-go procedures for legislation affecting direct spending or receipt through 1995. CBO estimates that enactment of

S. 272 would not affect direct spending or receipts. Therefore, pay-as-you-go procedures would not apply to the bill.

7. Estimated cost to State and local governments: None.

8. Estimated comparison: None.

9. Previous CBO estimate: None.

10. Estimate prepared by: David Hull and Marjorie Miller.

11. Estimate approved by: James L. Blum, Assistant Director for Budget Analysis.

Regulatory Impact Statement

In accordance with paragraph 11(b) of rule XXVI of the Standing Rules of the Senate, the Committee provides the following evaluation of the regulatory impact of the legislation, as reported.

NUMBER OF PERSONS COVERED

This legislation provides additional funding for research and development in high-performance computing. This will not result in new regulations, because the additional funding provided by the legislation would be distributed according to existing regulations regarding NSF research grants and NASA contracts. These regulations would apply only to those persons and companies which choose to apply for this funding.

ECONOMIC IMPACT

This legislation authorizes $1.019 billion in additional Federal spending for FY 1992–96. By providing for improved inter-agency coordination, this legislation should improve the effectiveness of Federal research and development on high-performance computing.

This legislation also requires NIST to develop guidelines and standards to provide for interoperability of Federal computer networks and for common user interfaces to systems. These guidelines should be cost-effective in increasing the usefulness of Federal networks and systems used by the Federal Government.

PRIVACY

This legislation will not have any adverse impact on the personal privacy of individual Americans. The creation of the NREN and associated databases will make existing Federal scientific data bases (including economic data and census data) more accessible to users throughout the country, but personal data already protected by rules and regulations (e.g. tax returns and individual census forms) will remain confidential.

PAPERWORK

This legislation requires FCCSET to submit a five-year program plan to the President and the Congress on the National HPC Program, which shall be revised at least every two years. The plan is to be accompanied by a report on progress made in fulfilling the plan. In addition, FCCSET shall report, without one year of enactment of the legislation act, on NREN policies regarding pricing, security, privacy, and commercialization of the network. The Department of Commerce (DOC) shall report to Congress on whether Fed-

eral procurement regulations discourage the development of better software development tools.

SECTION-BY-SECTION ANALYSIS

SECTION 1.—SHORT TITLE

This section states that the reported bill may be cited as the "High-Performance Computing Act of 1991."

SECTION 2.—FINDINGS AND PURPOSES

This section contains the Congressional findings and purposes of the legislation. Under subsection (a), the Congress finds: that advances in computer technology are vital to the prosperity, national and economic security, and scientific advancement of the United States; that the United States currently leads the world in high-performance computing and its applications, but that lead is being challenged by foreign competitors; that further research and development, training, improved computer networks, and more effective technology transfer are necessary for the United States to reap the benefits of high-performance computing; that improved interagency coordination and planning of high-performance computing programs could enhance their effectiveness; that a 1989 report by the Office of Science and Technology Policy on high-performance computing provides a framework for a multi-agency program; and that such a program would provide computing resources and information needed by American researchers and educators and would demonstrate the use of advanced computer and other communications technology in improving the national information infrastructure.

Subsection (b) states that the purpose of the bill is to ensure the continued leadership of the United States in high-performance computing and its applications. This purpose requires that the Federal Government expand Federal support for high-performance computing in order to establish a high-capacity national research and education computer network; expand the number of researchers, educators, and students who can use high-performance computing resources; make data bases and other services available through such a network; stimulate research on software technology; promote use of computer software tools and applications software; accelerate development of more powerful supercomputers and other advanced computer systems; promote application of high-performance computing to "Grand Challenges" of science and engineering; and provide for basic research and education in high-perormance compting. In addition, the Federal Government must improve planning and coordination of Federal research and development on high-performance computing.

SECTION 3.—DEFINITIONS

Definitions of "Director" (the Director of OSTP) and "Council" (FCCSET) are provided.

SECTION 4.—NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM

This section amends the National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6601 et seq., hereinafter referred to as "the Science Act") in order to establish a National HPC Program coordinated by OSTP. This section would add a new title VII to the end of the Science Act with a new section 701.

New subsection (a) of new section 701 mandates a five-year National HPC Plan (hereinafter the "Plan"), which under new subsection (a)(1) is to be developed and implemented by the President, through FCCSET. FCCSET is chaired by the Chairman of OSTP, who is traditionally also the President's Science Advisor. The Plan is to be submitted within one year after enactment of the legislation and is to be resubmitted upon revision at least once every two years thereafter.

Under new subsection (a)(1), FCCSET also shall provide for interagency coordination of the Federal HPC Program established by new title VII. FCCSET is currently charged with addressing research issues and coordinating research programs that involve more than one Federal agency. For instance, in recent years, FCCSET has provided high-level coordination on global change research. The National Global Change Research Program can serve as a model for the National HPC Program. As with global change research, high-performance computing involves several agencies, and there is no one agency with the expertise, breadth of authority, and facilities to oversee all Federal efforts in the field. FCCSET provides a mechanism for building on existing agency programs, preventing duplication of effort, and identifying previously unaddressed problems, without establishing a new bureaucratic entity. In addition, building on existing agency programs, rather than creating a separate agency for high-performance computing, would ensure that new developments in high-performance computing are utilized by individual agencies to accomplish their different missions.

Under new subsection (a)(2), the Plan is to establish the goals and priorities for a National HPC Program and set forth the roles and computer research budgets of the agencies involved. The Committee expects that the Plan would be similar to that presented in the 1989 OSTP report, "The Federal High-Performance Computing Program," although under this subsection it also is to include a budget showing the level of funding for each of the activities undertaken in support of the HPC program by each of the agencies involved and provide an inventory of what high-performance computing programs are currently underway throughout the Federal Government that could contribute to the National HPC Program.

New subsection (a)(3) requires that the Plan be accompanied by (1) a summary of the achievements of Federal high-performance computing research and development efforts during the preceding fiscal year, (2) an analysis of the progress made toward achieving the goals and objectives of the Plan, and (3) any recommendations regarding additional action or legislation which may be required to assist in achieving the purposes of this bill.

Under new subsection (a)(4), the Plan is to summarize the activities of NSF, DOC (particularly NIST, NOAA, and the National Telecommunications and Information Administration), NASA, DOD (particularly DARPA), DOE, the Department of Health and Human Services (particularly the NIH and the National Library of Medicine (NLM)), the Department of the Interior (particularly the U.S. Geological Survey (USGS)), the Department of Education, the Department of Agriculture (particularly the National Agricultural Library), and other appropriate agencies. New subsection (a)(5) specifies that the Plan is to take into account the present and planned activities of the Library of Congress, as deemed appropriate by the Librarian of Congress.

The HPC Program should build on the existing research and development programs of the participating agencies. Clearly, the roles of the agencies will evolve over time.

NSF programs impact the activities of all science and engineering disciplines by providing computing and networking infrastructure support and by developing enabling technologies for advanced computing and communications platforms and paradigms. In the area of high-performance computing systems, NSF-funded research will be initiated on new architectures and systems optimized for specific research applications. Research on advanced software will include work on database applications, Grand Challenge applications software, numeric and symbolic computing, algorithm development, optimization of applications software for new parallel computers, scientific visualization, automated programming tools, and new methods of scientific and technical information exchanges. NSF will coordinate deployment of the NREN, accelerating the harmonizing of multiple agency networks and protocols into a single NREN. NSF will support multidisciplinary basic research and university infrastructure for computer science, computer engineering, computational science and engineering, and information sciences. To increase the human resource pool in computing hardware and software systems area, support will be expanded for graduate and post-doctoral positions.

The goal of NASA's program is to accelerate the development and application of high-performance computing technologies to meet NASA's science and engineering requirements. In cooperation with the other Federal agencies, NASA's program will deploy teraflops computer capabilities essential for computational design of integrated aerospace vehicle systems and for predicting long term global change, and will enable the development of massively parallel techniques for spaceborne applications.

DARPA, as the DOD lead agency for advanced technology research, will focus on developing the high-performance computing and networking technologies needed for the defense and the overall HPC Program. DARPA programs have produced both the computing and networking foundation for the HPC Program, including the first generation of scalable parallel computing systems and large scale computer networks, and the associated system software and supporting technologies. DARPA will continue to work with industry to pioneer the application of these new technologies within DOD and on a cooperative basis with other Federal agencies. In addition, DARPA will work closely with the research laboratories and

other users and developers of high-performance computing technology within DOD.

DOE will be an early customer of systems with advanced architectures and will evaluate these systems with respect to energy-related applications, and will support research and development on algorithms and systems software for new, advanced computing systems. DOE will fund several Grand Challenge collaborations, initiate a software component and tools program with strong industrial participation, and initiate an applications-driven computational research program. DOE will participate in and contribute to the interagency NREN. The Energy Science Net (ESNet) will provide quality network access to the NREN for energy research facilities. DOE will continue to play an important role in education at the K-12, undergraduate, graduate, and post-graduate levels.

The goal of NIST's activities in high-performance computing is to develop hardware performance monitoring tools, promote "open system" software, and support a classification system for indexing and distributing scientific software so that industry and the research community can use effectively the power of high-performance computing. NIST will develop and speed commercialization of network protocols and security mechanisms that can achieve the desired gigabit speeds on future versions of the NREN.

NOAA operational and research programs are directed toward weather prediction, ocean sciences, the Climate and Global Change Program, and the Coastal Oceans Program, as well as data management activities for all agency programs. The HPC Program will allow extensive development of new forecast models, studies in computational fluid dynamics, and the incorporation of evolving computer architecture and networks into the systems that carry out agency missions.

The EPA research progam is directed toward the advancement and dissemination of computational techniques and software tools which form the core of ecosystem, atmospheric chemistry and dynamics models. The models extend the computational capability of environmental assessment tools to handle multi-pollutant interactions and optimization of control strategies.

The NIH program includes molecular biology computing, creation, and transmission of digital electronic images, the linking of academic health centers via computer networks, the creation of advanced methods to retrieve information from life sciences databases, and training in biomedical computer sciences. The HPC Program will complement the Human Genome Project by providing new methods for computer-based analysis of normal and disease genes.

The Committee is particularly interested in the work being done at the NLM and elsewhere to use national computer networks for the sharing of biomedical research information. For instance, the NLM's Medline system provides references and abstracts from the medical literature to doctors throughout the country, providing an invaluable service, especially to doctors in rural areas far from major libraries. Ongoing research at the NLM is providing the technology needed for doctors thousands of miles apart to share X-ray images, CAT scans, PET scans, and other medical imagery. In

this way, a general practitioner will be able to get the opinion of specialists anywhere in the country.

The biomedical community clearly has much to gain from advances in high-performance computing and computer networks, and should be encouraged to use fully this technology. Unfortunately, relatively few laboratory-based biomedical researchers at universities, and almost no clinical researchers or health care practitioners, use the current Internet. At the same time, it is clear that new computer-based technologies, such as clinical imaging, are essential to accurate diagnosis and treatment, and to the conduct of biomedical research. Improved methods of communications among health care practitioners and life sciences researchers will facilitate basic and clinical research, and accelerate the search for cures of many human diseases.

Therefore, it is envisioned that within the Department of Health and Human Services, NIH and the NLM will establish the appropriate mechanisms to ensure the development of a biomedical component of the NREN and promote and facilitate the use of the NREN by the biomedical research community. The NREN will serve as an invaluable testbed for the development of networking applications for the health care community, since most Federal health care agencies (e.g., NIH and NLM) will be connected to the NREN as will many university medical centers, hospitals, and other medical facilities. It is clear that the medical community will promote actively development of high-speed commercial computer networks as doctors become more and more dependent upon medical imaging and as they recognize the potential of high-speed networking technology.

The USGS of the Department of the Interior both can contribute to and can benefit from the HPC Program. As the lead agency within the Federal Government for geographic information systems, the USGS has developed new, more sophisticated systems for creating and manipulating "electronic maps." Clearly, the advanced computer technology developed by the HPC Program can be readily applied in this area. In addition, the USGS manages the EROS Data Center which archives all Landsat data and many other types of remote-sensing data. More powerful computers, better database software, and particularly the NREN will help make data stored at the EROS Data Center more readily available and easier and less expensive to use.

The Department of Education has a role to play in the HPC Program in educating computer and computational scientists, in training users of high-performance computing, and in developing and promoting the use of educational applications of high-performance computing, especially high-speed computing. In particular, the Committee encourages the Department of Education, through its library programs, to initiate and fund projects that promote linkages between existing library and information science networks and the NREN. The benefits of this enhanced resource sharing among the networks are: improved end-user document delivery; improved interlibrary resource-sharing and electronic interlibrary loans; and improved communication between users on the NREN and users outside the NREN.

National libraries, like the Library of Congress, the NLM, and the National Agricultural Library, have long been at the leading edge of automation of library functions, creation and standardization of bibliographic and information data bases, and electronic transmittal of information about their holdings to libraries across the country via library networks. The National Agricultural Library, the Library of Congress, and the NLM are now experimenting with electronic formats for entire portions of their collections and exploring uses of the Internet. The advent of the NREN will permit new opportunities for the research and scholarly communities to benefit from these information resources in performing research and in the creation of new knowledge that will improve the U.S. economic competitiveness.

Several other agencies can and will participate in the HPC Program. Such agencies should be included in the Plan as the Chairman of FCCSET considers appropriate.

New subsection (a)(6) provides that the Plan shall identify how the agencies and departments can collaborate to: (1) ensure interoperability of networks; (2) improve software development; (3) expand efforts to improve federally-funded public-domain software; (4) cooperate, where appropriate, with industry in development and exchange of software; (5) distribute software among agencies and departments, and federally-funded software to State and local governments, industry, and universities; (6) distribute Federal agency data bases and information; (7) accelerate the development of high-performance computer systems; (8) help address "Grand Challenges" (defined in subsection (e)); (9) provide for educating students in computer-related fields; and (10) identify agency rules and policies that could be changed to improve utilization of Federal high-performance computing and networking facilities, and make recommendations to such agencies on appropriate changes. In addition, under new subsection (a)(7) the agencies shall define and implement a security plan, consistent with the Plan, for protecting Federal computer networks and information resources available through Federal research computer networks.

New subsection (b) of new section 701 provides that FCCSET will have the lead in developing and coordinating implementation of the Plan. At least once a year, the Chairman of FCCSET is to report to the President on how to improve implementation of the Plan. Working through the Executive Office of the President, and especially the Office of Management and Budget (OMB), FCCSET should provide the high-level coordination needed to direct and implement effectively the National HPC program. Under new subsection (b)(3), prior to the submission of the President's annual budget request, FCCSET shall review each agency and department's budget estimate to determine how it contributes to the implementation of the HPC program, and make the results of such review available to OMB in particular. This review is intended to guide OMB in determining each agency's budget for high-performance computing.

New subsection (c) requires that the Director of OSTP establish an advisory committee on high-performance computing, consisting of representatives of industry and academia. The advisory committee is to provide FCCSET with an assessment of progress made in

implementing the Plan, the need to revise the Plan, and other issues.

New subsection (d) requires each agency involved in the HPC program to include with its annual request for appropriations to OMB a report explaining how its high-performance computing activities contribute to implementation of the Plan. OMB is to review these reports and include, in the President's annual budget estimate, a statement on the portion of each agency's budget estimate allocated to high-performance computing activities.

Subsection (e) defines "Grand Challenge" as a fundamental problem in science and engineering, with broad economic and scientific impact, whose solution will require the application of high-performance computing resources.

SECTION 5.—THE NATIONAL RESEARCH AND EDUCATION NETWORK

Subsection (a) requires NSF, DOD, DOE, DOC, NASA, and other appropriate agencies to provide for establishment of the NREN, a national computer network capable of transmitting more than one billion bits of data (gigabits) per second. Such a network would connect more than half a million computer users at more than 1,000 colleges, universities, Federal laboratories, industry laboratories, libraries, and other institutions in all 50 States. Within the Federal Government, NSF shall have primary responsibility for connecting colleges, universities, and libraries to the NREN. NSF is to be lead agency responsible for coordinating the efforts of agencies involved in deploying the network. As such, it will be responsible for building consensus among the agencies on network standards and policies, in accordance with the general policy guidance provided by FCCSET.

NSF already serves as lead agency for the Internet, the precursor to the NREN. NSF's NSFNET is the largest component of the Internet and is growing rapidly, in part because NSF has been able to bring together hundreds of State, local, and private-sector networks within the NSFNET structure. It appears that the key to the success of the NSFNET has been the flexible, decentralized management of the network. While NSF funds the NSFNET "backbone," most users of NSFNET are connected to the network by regional networks, like SURANet or CERFNet, which are primarily funded by States and network users. NSF has cooperated and coordinated with the dozens of regional and local networks connected to the NSFNET backbone. In addition, NSF has worked closely and effectively with the communications and computer industries in expanding and upgrading its network.

Subsection (b) requires that the NREN provide users with appropriate access to supercomputers, computer data bases, other research facilities, and libraries. Access policies clearly would be determined by whoever owns or controls such resources.

According to subsection (c), the NREN is to be developed in close cooperation with the computer, telecommunications, and information industries and is to be designed, developed, and operated in collaboration with potential users in government, industry, and the education community, including researchers, librarians, educators, and information services providers.

Subsection (d) requires that the NREN be established in a manner that fosters and maintains competition within the telecommunications industry and promotes the deployment of interconnected high-speed data networks by the private sector. Accordingly, to the maximum extent practicable, operating facilities for the NREN should be procured on a competitive basis from private industry, and the NREN shall be phased into commercial operation as commercial networks can meet the networking needs of American researchers and educators. In addition, the agencies deploying the NREN are to promote research and development leading to deployment of commercial data communications and telecommunications standards.

One way to meet the goals enumerated in subsections (c) and (d) is to develop and operate the NREN in much the same way as NSFNET, which is a national computer network connecting the four NSF supercomputer centers and over 500 colleges and universities. NSF funds the high-speed (1.5 million bits per second), interstate NSFNET "backbone" which connects the supercomputer centers and other facilities. Regional networks, both private and nonprofit, connect the backbone to individual colleges and universities which in turn have their own local campus networks. The NSFNET backbone is managed by ANS, Advanced Networks and Services, a not-for-profit corporation created by MCI Telecommunications, IBM, and MERIT, a consortium of Michigan universities. ANS provides fiber optic telephone lines and computer hardware as well as technical expertise. This kind of industry-government-academia partnership provides for the rapid development of networking technology and its rapid dissemination.

Subsection (e) requires that the NREN, to the extent practicable, provide access to electronic information resources maintained by libraries, research facilities, publishers, and affiliated organizations. To encourage use of the NREN by commercial information and network service providers, mechanisms for charging for the use of copyrighted material available over the NREN are to be implemented, where technically feasible. These mechanisms should be developed and implemented in collaboration with private-sector information providers, as soon as possible. They need not (and, preferably, should not) await completion of the OSTP Director's report on commercial access, copyright and related issues, as required by subsection (i) of this section within one year after enactment. These mechanisms should not be implemented without due consideration of both the rights of authors and the rights of users of copyrighted material, and specifically, of the fair use of copyrighted works for teaching, scholarship, or research. The institution of charging mechanisms will be technically difficult when gigabit networking technology is in its infancy, but the inability to install such mechanisms should not delay the deployment of a gigabit network.

Subsection (f) designates DARPA as the lead agency for developing the gigabit networking technology needed to create the NREN. DARPA has a long history of funding computer network technology. In the late 1960s, DARPA helped create ARPANET, the first national computer network. Networking technology developed with DARPA funding has been applied broadly in both the military and the civilian sector. In its lead agency role, DARPA will continue to

provide funding for development of NREN technology and will be responsible for coordinating, under the aegis of FCCSET, with other agencies in developing technology, protocols, and applications for the NREN.

Subsection (g) requires that FCCSET, within one year after the enactment of the bill, shall develop goals, strategy, and priorities for the NREN; identify the roles of Federal agencies and departments in implementing the NREN; and provide a mechanism to coordinate the activities of Federal agencies, States, and public and private network service providers in deploying the NREN. FCCSET also is to oversee the operation and evolution of the NREN and manage connections between computer networks of Federal agencies. In this role, FCCSET is to determine conditions for access to the NREN and identify how existing and future computer networks of Federal agencies could contribute to the NREN. The President is to report to Congress within one year after enactment of this legislation on the implementation of this subsection.

At present, the Internet is coordinated by the Federal Networking Council (FNC), which consists of representatives of the various Federal agencies contributing to and using the Internet. The FNC was created under the auspices of NSF and has proven to be a very successful mechanism for coordinating the networking activities of the participating agencies. By pooling resources and sharing networks, these agencies have been able to save money while creating a network far larger and more capable than any one agency could afford on its own.

The successful interagency coordination needed to create and maintain the Internet would not be possible without the spirit of cooperation fostered by the FNC. While NSF created the FNC and is responsible for facilitating cooperation between the member agencies, no one agency is "in charge" in the sense that it can dictate to another agency how that agency must operate its mission-related networks. Any agency is free to disconnect its networks from the Internet, if it believes that it more effectively can meet its networking needs in that way.

The management structure of the Internet continues to evolve and will change as more participants, especially from the private sector, become involved. The bill requires FCCSET to establish a mechanism to coordinate deployment of the NREN and to oversee the operation and evolution of the NREN. The Committee anticipates that FCCSET will do this through the FNC or its successors, so that the excellent cooperation that now exists between contributors to the network will continue.

Subsection (h) directs NIST, NSF, and DARPA to adopt a common set of standards and guidelines to provide interoperability, common user interfaces to systems, and enhanced security for the NREN, so that different Federal agency networks can be linked together. In addition, NSF, NASA, DOE, DOD, DOC, the Department of the Interior, the Department of Agriculture, the Department of Health and Human Services, EPA, and other appropriate agencies are authorized under this subsection to allow recipients of Federal research grants to pay for computer networking expenses. Currently, most Federal agencies forbid grant recipients from using grant money for any type of telecommunications expenses. Providing

funding for computer networking would increase the productivity of researchers, who are increasingly dependent upon computers and computer networks to manipulate, search, store, and share their data.

Subsection (i) requires that the Director of OSTP, through FCCSET, shall report of Congress on how the NREN can be funded, how it will be phased into commercial operation, how the security of resources available on the NREN and the privacy of users will be protected, and how commercial information service providers can use the NREN effectively.

SECTION 6.—ROLE OF THE NATIONAL SCIENCE FOUNDATION

Under subsection (a), NSF shall expand its traditional role in supporting basic research in universities and colleges, and in training scientists and engineers in computer science, computational science, library and information sciences, and electrical engineering. In particular, NSF is to provide funding to enable researchers to access supercomputers.

Prior to deployment of the NREN, NSF is directed to maintain, expand, and upgrade its existing computer networks, like NSFNET. Additional NSF responsibilities may include promoting development of information services and data bases available over such computer networks; facilitation of the documentation, evaluation, and distribution of research software over such computer networks; encouragement of continued development of innovative software by industry; and promotion of science and engineering education.

Under subsection (b), NSF also is to promote development of information services that could be provided over the NREN. NSF will help provide access to "digital libraries" of video programming, books and journals stored in electronic form, and other computer data. NSF can provide access to the NREN for commercial and non-profit information service providers and to other Federal agencies which maintain electronic data bases. Thus, NREN users will have access to commercial information services like Lexus-Nexis and Dialog, with appropriate mechanisms for charging customers of these services. NSF also is to provide for orientation and training of users of networks and data bases, by providing training software on networks and by providing experts to guide and teach users of networks. While this legislation does not provide the funding needed to create, upgrade, or maintain electronic data bases, it will fund the development of the technology and standards needed to build and improve such data bases and make them more accessible and easy-to-use.

The information services made available on the NREN is to be provided with appropriate protection for the copyright and other intellectual property rights of information providers and NREN users. The implementation of clear copyright policies, and of appropriate remuneration mechanisms for information providers, are critical if commercial information providers are to rely on the NREN for dissemination of their products.

While S. 272 will provide for new mechanisms for improving the dissemination of data bases of Federal Government information,

this legislation does not change Federal information dissemination policies. The legislation neither requires nor forbids any agency to develop or disseminate to the public any particular information products or service. Information policy statutes, regulations, and directives continue to govern the objectives, procedures, and conditions of information dissemination by agencies and departments.

Subsection (c) provides authorizations for NSF in addition to the amounts authorized under other law. The amounts authorized (in millions of dollars) are:

	Fiscal year—					Total
	1992	1993	1994	1995	1996	
Total	46	88	145	172	199	650
For networking	15	25	55	50	50	195

SECTION 7.—ROLE OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Under subsection (a), NASA shall continue to conduct basic and applied research in high-performance computing, particularly in the field of computational science, with emphasis on aeronautics and processing of remote sensing and space science data.

In addition to amounts authorized under other laws, there is authorized under subsection (6) to NASA (in millions of dollars) the following amounts:

Fiscal year:	
1992	22
1993	45
1994	67
1995	89
1996	115
Total	338

SECTION 8.—ROLE OF THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Under subsection (a), NIST, in cooperation with other agencies, is directed to adopt standards and guidelines, and develop measurement techniques and test methods, for the interoperability of high-performance computers in networks and for common user interfaces to systems to enable government networks to be linked together. These standards will be adopted with the advice and input of private industry and shall provide enhanced security for the NREN. In addition, NIST is to be responsible for developing benchmark tests and standards for high-performance computers and software, and shall continue to fulfill its responsibilities under the Computer Security Act of 1987. Furthermore, work being done at NIST, such as measurement research and development needed to develop advanced optical fibers and optoelectronic components for high-performance optical fiber communications, will contribute to the National HPC Program.

In addition to amounts authorized under other laws, there is authorized under subsection (b) to NIST (in millions of dollars) the following amounts:

Fiscal year:	
1992	3
1993	4
1994	6
1995	8
1996	10
Total	31

SECTION 9.—STUDY ON IMPACT OF FEDERAL PROCUREMENT REGULATIONS

This section requires that, within one year of enactment of this legislation, the Secretary of Commerce shall report to Congress on the impact of Federal software regulations which require that contractors share the rights to proprietary software development tools and on whether such procurement regulations discourage the development of better software development tools. It is expected that this report will be written in consultation and cooperation with DOD, NASA, and other agencies which contract for large amounts of customized software.

At present, in most agencies, if a contractor sells software to the government, that contractor not only must provide the software itself, but also must provide the software used to develop it. Today many software companies use proprietary software tools to streamline software development, and these tools can require more money and manpower to make than the software that they are used to produce. Because of anachronistic procurement regulations, companies are discouraged from developing better, easier-to-use software tools, and if they do develop them, they do not use them to produce government software, resulting in the government's paying higher prices for lower-quality software.

SECTION 10.—MISCELLANEOUS PROVISIONS

Subsection (a) exempts computer systems used to process classified information from the provisions of this bill, unless the appropriate Federal agency or department head determines that the provisions should apply.

Subsection (b) directs Federal agencies and departments, where appropriate, to procure prototype or early production models of new high-performance computer systems and subsystems to stimulate hardware and software development. In the 1970's, several Federal agencies, including DOE, DOD, and NSA purchased prototype or early production models from American computer manufacturers. Such purchases gave fledging companies like Cray Research, Inc., the money they needed to become viable companies. Equally important, Cray and other companies were able to have their machines tested by scientists and engineers working on real problems. The first Cray 1 was installed at Los Alamos National Laboratory before Cray had been able to complete the systems software for the new machine.

Unfortunately, in recent years, many agencies have been discouraged from making purchases of prototypes by regulations stemming from the so-called "Brooks Act" and other laws regulating Federal purchases of computer equipment. Althouth this was not the intent of the Brooks Act, regulations resulting from that Act make it difficult for an agency to contract to buy a supercomputer before it is in production. Unfortunately, without such pre-production contracts, a fledgling supercomputer company is unlikely to survive. This section makes clear that Federal agencies can and should buy prototype and early production models of leading-edge, high-performance computer systems and subsystems. Such purchases provide critically-needed opportunities to test new design concepts and can be particularly effective in promoting commercialization of leading-edge technologies.

The bill highlights the need for special emphasis on pre-production purchases of advanced display technology (which will be needed for HDTV and, after that, digital TV), supercomputers with alternative architectures, advanced storage devices, and very high-speed (multi-gigabit-per-second) communications links. DARPA has played a particularly important role in funding research and development contracts for such prototypes where the commercial marketplace would not supply the speculative capital needed for such worthy development projects. While this legislation encourages DARPA and other agencies to purchase a limited number of initial prototype machines, it is important that Federal agencies not pick corporate "winners and losers" when procuring equipment that is beyond the prototype stage.

Changes in Existing Law

In compliance with paragraph 12 of rule XXVI of the Standing Rules of the Senate, changes in existing law made by the bill, as reported, are shown as follows (existing law proposed to be omitted is enclosed in black brackets, new material is printed in italic, existing law in which no change is proposed is shown in roman):

National Science and Technology Policy, Organization and Priorities Act of 1976

Titles I through VI * * *

TITLE VII—NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM

NATIONAL HIGH-PERFORMANCE COMPUTING PLAN

Sec. 701. (a)(1) The President, through the Federal Coordinating Council for Science, Engineering, and Technology (hereafter in this title referred to as the "Council"), shall, in accordance with the provisions of this title—

(A) develop and implement a National High-Performance Computing Plan (hereafter in this title referred to as the "Plan"); and

(B) provide for interagency coordination of the Federal high-performance computing program established by this title.

The Plan shall contain recommendations for a five-year national effort and shall be submitted to the Congress within one year after the date of enactment of this title. The Plan shall be resubmitted upon revision at least once every two years thereafter.

(2) The Plan shall—

(A) establish the goals and priorities for a Federal high-performance computing program for the fiscal year in which the Plan (or revised Plan) is submitted and the succeeding four fiscal years;

(B) set forth the role of each Federal agency and department in implementing the Plan; and

(C) describe the levels of Federal funding for each agency and department and specific activities, including education, research activities, hardware and software development, establishment of a national gigabits-per-second computer network (to be known as the National Research and Education Network), and acquisition and operating expenses for computers and computer networks, required to achieve the goals and priorities established under subparagraph (A).

(3) Accompanying the Plan shall be—

(A) a summary of the achievements of Federal high-performance computing research and development efforts during that preceding fiscal year;

(B) an analysis of the progress made toward achieving the goals and objectives of the Plan; and

(C) any recommendations regarding additional action or legislation which may be required to assist in achieving the purposes of this title.

(4) The Plan shall address, where appropriate, the relevant programs and activities of the following Federal agencies and departments:

(A) the National Science Foundation;

(B) the Department of Commerce, particularly the National Institute of Standards and Technology, the National Oceanic and Atmospheric Administration, and the National Telecommunications and Information Administration;

(C) the National Aeronautics and Space Administration;

(D) the Department of Defense, particularly the Defense Advanced Research Projects Agency;

(E) the Department of Energy;

(F) the Department of Health and Human Services, particularly the National Institutes of Health and the National Library of Medicine;

(G) the Department of the Interior, particularly the United States Geological Survey;

(H) the Department of Education;

(I) the Department of Agriculture, particularly the National Agricultural Library; and

(J) such other agencies and departments as the President or the Chairman of the Council considers appropriate.

(5) In addition, the Plan shall take into consideration the present and planned activities of the Library of Congress, as deemed appropriate by the Librarian of Congress.

(6) The Plan shall identify how agencies and departments can collaborate to—

(A) ensure interoperability among computer networks run by the agencies and departments;

(B) increase software productivity, capability, portability, and reliability;

(C) expand efforts to improve, document, and evaluate unclassified public-domain software developed by federally-funded researchers and other software, including federally-funded educational and training software;

(D) cooperate, where appropriate, with industry in development and exchange of software;

(E) distribute software among the agencies and departments;

(F) distribute federally-funded software to State and local governments, industry, and universities;

(G) distribute Federal agency data bases and information;

(H) accelerate the development of high-performance computer systems, subsystems, and associated software;

(I) provide the technical support and research and development of high-performance computer software and hardware needed to address Grand Challenges in astrophysics, geophysics, engineering, materials, biochemistry, plasma physics, weather and climate forecasting, and other fields;

(J) provide for educating and training additional undergraduate and graduate students in software engineering, computer science, library and information science, and computational science; and

(K) identify agency rules, regulations, policies, and practices which can be changed to significantly improve utilization of Federal high-performance computing and network facilities, and make recommendations to such agencies for appropriate changes.

(7) The Plan shall address the security requirements and policies necessary to protect Federal research computer networks and information resources accessible through Federal research computer networks. Agencies identified in the Plan shall define and implement a security plan consistent with the Plan.

(b) The Council shall—

(1) serve as lead entity responsible for development of the Plan and interagency coordination of the program established under the Plan;

(2) coordinate the high-performance computing research and development activities of Federal agencies and departments and report at least annually to the President, through the Chairman of the Council, on any recommended changes in agency or departmental roles that are needed to better implement the Plan;

(3) review, prior to the President's submission to the Congress of the annual budget estimate, each agency and departmental budget estimate in the context of the Plan and make the results of that review available to the appropriate elements of the Executive Office of the President, particularly the Office of Management and Budget; and

(4) consult and coordinate with Federal and State agencies, and research, educational, and industry groups, conducting research on and using high-performance computing.

(c) The Director of the Office of Science and Technology Policy shall establish an advisory committee on high-performance computing consisting of prominent representatives from industry and academia who are specially qualified to provide the Council with advice and information on high-performance computing. The advisory committee shall provide the Council with an independent assessment of—

(1) progress made in implementing the Plan;

(2) the need to revise the Plan;

(3) the balance between the components of the Plan;

(4) whether the research and development funded under the Plan is helping to maintain United States leadership in computing technology; and

(5) other issues identified by the Director.

(d)(1) Each appropriate Federal agency and department involved in high-performance computing shall, as part of its annual request for appropriations to the Office of Management and Budget, submit a report to the Office identifying each element of its high-performance computing activities, which—

(A) specifies whether each such element (i) contributes primarily to the implementation of the Plan or (ii) contributes primarily to the achievement of other objectives but aids Plan implementation in important ways; and

(B) states the portion of its request for appropriations that is allocated to each such element.

(2) The Office of Management and Budget shall review each such report in light of the goals, priorities, and agency and departmental responsibilities set forth in the Plan, and shall include, in the President's annual budget estimate, a statement of the portion of each appropriate agency or department's annual budget estimate that is allocated to each element of such agency or department's high-performance computing activities.

(e) As used in this section, the term "Grand Challenge" means a fundamental problem in science and engineering, with broad economic and scientific impact, whose solution will require the application of high-performance computing resources.

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